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| DES-WMB Policy Number: 008 ****DRAFT**** | | Date Printed: 4/18/2008 |
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New Hampshire Department of Environmental Services Interim Chlorophyll Criteria for Lakes

Situation

1. Chlorophyll is a pigment in all plants. Measuring chlorophyll in lake water provides an estimate of the phytoplankton (floating algae) biomass in the lake.
2. Excessive algal growth (high biomass and high chlorophyll values) can impair the aesthetic enjoyment (swimming use) of a lake.
3. New Hampshire's surface water quality regulations (Chapter 1700) currently have no chlorophyll criteria. DES does have a plan for adopting nutrient criteria by the end of 2004, which will include a chlorophyll criterion.
4. The purpose of this policy is to establish an interim chlorophyll criterion for lakes that can be used in the 2004 assessments for 305(b) and 303(d) reporting purposes. It also provides a numerical chlorophyll translator for the narrative criteria of Env-Ws 1703.03(c)(1) (to paraphrase, surface waters shall be free from substances that interfere with recreational activities).

Policy

1. The chlorophyll criterion for lakes shall be 15 mg/m³ (ppb).
2. Lake water samples for analysis shall be composites of the epilimnion of stratified lakes or of the entire oxygenated water column of unstratified lakes (see SOP for Lake Trophic Survey Program).
3. Samples shall be collected between May 24 and September 15.
4. The magnitude of exceedance criterion shall be 30 mg/m³.
5. Assessment of use support (primary contact) shall be according to the current version of the NHDES CALM. Currently that means a minimum of 10 samples and no more than 2 out of 10 may exceed 15 mg/m³ and no more than 1 may exceed 30 mg/m³.

Justification and Supporting Data for the Selected Criteria

As a measure of phytoplankton biomass, chlorophyll can indicate conditions that may impair the swim use. Establishing a numerical chlorophyll value that impairs swimming, however, is clearly a judgement call. People have differing perceptions of acceptable conditions for swimming relative to the aesthetic characteristics of the water (water clarity, presence of scums, etc). In the future, DES proposes to base the chlorophyll criterion on lake user perception surveys where the public provides input on chlorophyll conditions that impair their use of the lake. Until user perception data is available, DES needs to select an interim chlorophyll criterion.

One approach to selecting a criterion is to select a chlorophyll value that represents eutrophic conditions. The table below provides a number of literature values for chlorophyll for the three trophic classes.

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| source | oligotrophic | mesotrophic | eutrophic |
|---|--------------|-------------|-----------|
| ¹ Sakamoto, 1966 | 0.3-2.5 | 1 – 15 | 5 – 140 |
| ¹ National Academy of Sciences, 1972 | 0 – 4 | 4 – 10 | > 10 |
| ¹ Dobson et al., 1974 | 0 – 4.3 | 4.3 – 8.8 | > 8.8 |
| USEPA, 1974 | < 7 | 7 – 12 | > 12 |
| ² Schindler, 1974 | | | > 30 |
| ³ Hern, et al., 1981 | < 2.3 | 2.3 – 6.4 | > 6.4 |
| ⁴ Porcella and Bishop, 1975 | < 26 | 26 – 52 | > 52 |
| Smith, undated | < 4.8 | 4.8 – 8.5 | > 8.5 |
| Weber, undated | 0 – 3 | 3 – 20 | > 20 |
| ⁵ Carlson, 1977 | < 2.6 | 2.6 – 6.4 | > 6.4 |
| ⁶ Lee, et al., 1981 | 0 – 2 | 2.1 – 9.9 | > 9.9 |
| ⁷ Wetzel, 2001 | 0.3 – 4.5 | 3 – 11 | 3 – 78 |
| ⁸ Brezonik, 1976 | 1.3 – 3.2 | 1.8 – 9 | 3.5 – 93 |
| ⁸ Vallentyne, 1969 | < 5 | 5 – 10 | > 10 |
| Craycraft and Schloss, undated | < 3 | 3 – 7 | > 7 |
| NHDES, 1996 | < 4 | 4 – 15 | > 15 |

¹ as reported in USEPA, 1974

² note # 6 at end of paper

³ using the 10 and 20 ppb total phosphorus of Vollenweider separating the trophic classes and the regression equations of Jones and Bachman

⁴ 26 and 52 are expressed as the permissible and dangerous levels in the paper

⁵ assumes a TSI < 40 is oligotrophic and a TSI > 50 is eutrophic (see discussion by Reckhow, 1979)

⁶ oligo-meso and meso-eutro categories were lumped into mesotrophic

⁷ range of chl values in the trophic states as defined by experienced investigators

⁸ as reported in Carlson, 1979

An evaluation of the data in the table suggests that a chlorophyll value in the range of 8 to 10 mg/m³ or ppb (median value is 9.4 – average of the two middle values of 8.8 and 9.9) is the most commonly used value to represent the beginning of eutrophic conditions. But we should recall that eutrophic (particularly the beginning of eutrophic conditions) is not synonymous with not supporting the swim use. New Hampshire has many eutrophic lakes that residents swim in and are very happy to swim in. Prior to the passage of the Clean Water Act, a few New Hampshire lakes received point source discharges that supported annual algal blooms with surface scums and with chlorophyll values in the 30 to 50 range and with pulses as high as 100. Although people continued to swim in these waters, these chlorophyll levels were clearly a nuisance and resulted in citizen complaints and decreased attendance at a state beach (Kezar). The swimming use was impaired.

In selecting an impairment chlorophyll concentration of 15 mg/m³, we are selecting a value that is slightly higher than the beginning of eutrophic conditions but clearly much less than a concentration that would significantly impair the swim use. The argument that such a criterion will not protect oligotrophic lakes with low chlorophyll values begs the question of the purpose

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of water quality criteria. Criteria are designed to protect a designated use – not to protect existing conditions. Criteria for many parameters exceed what is found in most NH lakes. It is the antidegradation provisions of the surface water quality regulations that are designed to protect existing high quality waters. DES will continue to work with all lakes through our education, outreach and volunteer monitoring programs to educate people on ways to protect their lakes and maintain existing high quality.

Early 305(b) reports (1996 and before) used chlorophyll as an indicator for swimming use support for lakes. Chlorophyll values > 30 were listed as “not support” and values from 20 to 30 were listed as “partially support”. These assessments were based on the single most recent chlorophyll reading for the lakes. The use of chlorophyll for these assessments was criticized because there was no numerical water quality criterion for chlorophyll in the NH WQ regulations. Later 305(b) reports (1998, 2000) used the narrative “*frequent and persistent algal blooms ... that interfere significantly with swimming ...*” to determine “partial support” for swimming. This was more in line with the general water quality criteria (Env-Ws 1703.03(c) that surface waters shall be free of substances that form scums, result in the dominance of a nuisance species or interferes with recreational activities (paraphrased). Under this scenario, all lakes were at least partially supported and only those lakes with annual nuisance algal blooms were less than fully supported. A lake with a chlorophyll concentration of 20 to 30 ppb or more would be listed as fully supporting unless nuisance algal scums were present essentially every year. The 2002 305(b) report used a chlorophyll concentration of 25 ppb to indicate impairment and, for the first time, required a minimum of 10 samples for assessment. This was more restrictive than the narrative criteria used in the previous two assessments. The proposed criteria of 15 ppb, which will be used for the 2004 assessments, is even more restrictive.

Given the literature values for beginning eutrophic conditions and the above history of the use of chlorophyll for assessing lakes in New Hampshire, the chlorophyll criteria of 15 ppb is a reasonable and rational value for assessing use support for swimming.

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